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PROSPECTS FOR INCREASED AFRICAN COAL PRODUCTION AND UTILIZATION

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I. THE LAGOS PLAN OF ACTION AND PROGRAMME OF THE INDUSTRIAL DEVELOPMENT DECADE FOR AFRICA

A. Growth Objectives of the Lagos Plan of Action

The Lagos Plan of Action (LPA) and the Final Act of Lagos (FAL), whose fundamental objectives are to lessen the excessive external dependence of African economies and achieve self-sustained growth in the African region were adopted against the background of worsening economic situation and poor development prospects for African countries.

The Plan envisages among other things the attainment of sovereignty over natural resources by African member States through the increased use of indigenous natural resources.

B. Programme for the Industrial Development Decade for Africa

The programme intends to lay the foundation for the phased development of : Building materials, metallurgical, mechanical, chemical and energy industries which offer a great potential for increased production and utilization of African coal.

II. COAL RESOURCES IN AFRICAN COUNTRIES

A. Coal Resources and Production

African coal resources (anthracite, bituminous and lignite) are concentrated in the Eastern and Southern African subregion. The most important coal deposits are found in the continental formation called Karro system of the Southern African subregion. Karoo coals are generally bituminous high ash coals. Past resources are found in Central Africa. There are also coal prospects in West Africa. In North Africa the coal reserves have not been fully evaluated.

(i) Algeria

Coal formations are found in the Colom - Bechar - Kenadza and Aballa basins. Reserves are estimated at one billion tonnes of medium volatile coking coal. The sulphur content is mainly organic and therefore cannot be reduced by washing. Production from Bechar - Kenadza coal fields reached a figure of 300,000 in 1960 but dropped to 13,000 tons in 1970 because of resources depletion. By 1975 mining stopped because resources were finally depleted. Development work in a new area is being carried out with a view to extracting 500,000 tons of coal per year for local consumption. Meanwhile Algeria imports up to 1.2 million tonnes of coking coal annually from USA, West Germany and Poland.

Demand for coking coal is likely to rise from the current 1.2 million to 1.8 million tonnes in 1985. The Algerian industry is expected experts to raise steel production from the current one million to two million tonnes by 1985.

(ii) Angola

Coal resources of Angola are not documented. However the tectonics of the sedimentary formations indicate numerous and important indications and accumulations of hydrocarbons. An asphalt deposit is reported at Libongo - Cuxites with a 10-15 per cent asphalt content. Numerous oil and gas deposits have been discovered. Oil and gas are produced in Cabinda.

(iii) Botswana

Coal has been known to exist in Botswana since the begining of the last century. Exploration for coal was conducted between 1952 and 1962. Main coal reserves are in the Serowe - Morupule and Mmamabula areas of eastern Botswana. Botswana coal has a high ash content with medium calorific value. The best coal so far found occurs within the Morupule area where approximately 6.5 billion tonnes of In-situ coal have been identified. In the Mmamabula area 470 million tonnes of coal have been identified. Very large resource of high ash bituminous coal have been found in the Dutlwe and Lotlhakeng areas. Beneficiation tests have indicated that coal suitable for the export markets can be produced. However coal with satisfactory coking properties has not yet been found.

Table 1 below summarises the coal resources of Botswana.

The Colliery at Morupule, while capable of a considerably larger production is at present producing about 300,000 tonnes of coal per year for the local market which consists of the power station and smelter at Selebi-Phikwe and power station at Gaborone.

Table 1 : Coal Resources of Botswana

Coal Field	Area (Square kilometers)	Total In-Situ Resources (mil.tons)	Moisture (%)	Ash (%)	Volatiles (%)	Fixed carbon (%)	Calorific Value (MJ/kg
Morupule	520	6,500	4.63	23.27	27.50	44.60	22.92
Mmamabula	260	3,000	5.90	16.80	25.05	52.65	24.11
Moijabana	250	1,300		30.00			21.00
Letlhakeng	660	2,400					23.60
Dutlwe	350	2,000		12.50			25.00
Total	2,040	15,200					

Source : The Coal Resources of Botswana, Geological Survey Republic of Botswana

(iv) Egypt

Detailed coal exploration conducted between 1958 and 1962 resulted in the discovery of coal deposits of Ayun Musa, Wadi Thora, and Maghara in Sinai Peninsula. The Ayun Musa deposit is estimated at 37 million tons of coal. Unfortunately the coal is found at great depth with high pressure underground water in a complicated geological structure. The deposit is considered uneconomic.

The Thora coal deposit is estimated at 15 million tonnes of proven reserves and 60 million tonnes of probable reserves. The deposit has not been evaluated. The Maghara coal deposit is estimated at 52 million tons of total resources (of which 36 million are workable). The Maghara coal has coking properties and is considered suitable as a blend with imported coking coals. Characteristics of Egyptian coal are summarized in table 2.

Exploitation of the Maghara coal is planned to resume in April 1986 with an ultimate installed capacity of 500,000 tonnes per year run-of-mine coal. Egypt is currently importing 1.5 million tonnes of coking coal from Australia, USA and USSR. Demand for coking coal is estimated at 2.1 million by 1987. In view of expansion plans for the Egyptian iron and steel industry it is envisaged that more coking coal will be consumed by the year 2000 when Egypt is expected to produce about 11 million tonnes of Blast Furnace/Basic oxygen/BOF route crude steel.

Table 2 : Characteristics of Egyptian coal

Coal Deposit	Reserves (million tonnes) Proven	Probable	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed carbon (%)	Calorific Value Kcal/kg
Ayun Musa		37	12.40	16.15	41.10	30.15	5,820
Thora	15	60	2.00	39.00	22.00	37.00	4,053
Maghara	28	3	4.90	6.80	48.40	39.90	7,300

Source : Prospects for African co-operation in the coking coal for iron and steel and related industries; ECA 1983

(v) Ethiopia

Lignite reserves are reported in Gondar, Shoa and Wolo regions. These reserves have not been fully assessed. Natural gas and petroleum occurrences have been reported in the Red Sea and Ogaden regions.

(vi) Madagascar

Bituminous sandstones have been identified in the Diego Basin over an area of 5,000 square kilometers on shore and 20,000 square kilometers offshore. Similar deposits have been identified in the Majunga Basin over 44,000 square kilometers onshore and 23,000 square kilometers offshore.

Madagascar is one of the few countries in the world which posses oil sand (the others being Albania, Canada, Rumania, USA, USSR and Trinidad).

The oil sands are located at Bemolanga in the north-western region covering about 390 square kilometers. Contained hydrocarbons are estimated at 1.75 billion barrels 1/.

1/ McGraw-Hill Encyclopedia of Energy; Page 534 (1976)

(vii) Mali, Bénin, Niger, Sierra Leone and Upper Volta

Lignite deposits have been reported. These deposits have not been evaluated. Detailed exploration and subsequent exploitation will primarily be influenced by the local and subregional demand.

(viii) Malawi

The coal formation cover 90 square kilometers of area between Livingstonia and Chiweta. The coal field is broken up by several major fault zones. Exploitation possibilities are complicated by ground water conditions and variations in quality and seam thickness. Characteristics of Malawi coal are summarized in table 3. Workable coal seams exist within the Rtnaliru Basin and parts of the North Rukuni Basin. Reserves have not been estimated.

Table 3 : Characteristics of Malawi Coals

Coal Deposit	Moisture (%)	Volatiles (%)	Fixed carbon (%)	Ash (%)	Calorific Value (Btu/lb)
Kaziwiziwi	5.50	30.92	51.23	12.34	11,436
Chombe	1.30	21.85	52.36	24.09	10,339
Chizindiri	12.06	32.17	14.11	41.66	
Rumphi	2.66	29.78	49.55	17.01	11,370
Mean	4.22	23.73	49.03	32.36	8,690

Source : The Geology of the Uzumara Area
Geological survey Department; Ministry of Agriculture and Natural Resources, Malawi Government Printers; 1975 page 51.

(ix) Morocco

Coal resources are estimated at 120 million tonnes of in-situ reserves (of which 40 million tonnes are exploitable). The coal is located at Jerrada in the Oujda region. Exploitation is handled by a national company, les Charbonages Nord-Africains. Production includes anthracite, balls and briquettes. In 1976 anthracite production was 702,000 tonnes and that of balls and briquettes was 15,600 tonnes.

(x) Mozambique

The main coal basins are located in Tete and Niassa provinces. The most important being Moatize, Mucanha, Mucondra-Vuzi and Sourmoe basins. The Moatize basin has been designated as the coal producing centre up to 1990. Development of the Mucanha-Uzi will be undertaken after 1990. Mazaradzi and Sanangoe deposits have not yet been fully investigated.

Reserves of the Chipanga seam (the only one quantified so far) is estimated at 70 million tonnes proven and 150 million tonnes probable reserves. The whole of Moatize basin is thought to have 2 billion tonnes of coal. The reserves of Mucanha-Vuzi are placed at 3 billion tonnes. Characteristics of Mozambican coals are summarized in table below 4.

The Moatize coal mine is a state enterprise with the technical collaboration of the German Democratic Republic. Operations consist of an underground mine. Production in 1981 was 400,000 tonnes (out of which 21,000 tonnes were exported).

Table 4 : Characteristics of Mozambican coal

Coal Deposit	Moisture (%)	Volatile (%)	Fixed carbon (%)	Ash (%)	Calorific Value Btu/lb
Chipanga	1.38	16.00	50.30	22.30	11,830
Mucanha-Vuzi			34.65	12.01	

Source : Prospects for African co-operation in the coking coal for iron and steel and related industries; ECA 1983

(xi) Nigeria

The principal coal deposits lies along a 160 kilometer coal belt which runs in a northern direction from Inyi through Enugu, Ukwuka, Ezimo and Otukpa to Okaba, Ogboyaga and Dekina. Major coal fields are : Inyi-Enugu, Ezimo-Otukpa and Okaba-Ogboyaga. These coal fields have reserves estimated at 500-600 million tonnes. Lignites deposits are distributed along a 100 kilometer belt extending from Ase through Umuchia and Orlu to Ogwashi - Asaba then Obonka. The lignite reserves of the Ogwashi - Asaba - Obonka are estimated at 30 million tonnes. Characteristics of coal from major coal fields are summarize in table below 5.

The Nigerian coal corporation operate the Okpara and Onyeama underground mines together with Okaba and Orukpa open cast mines. Total coal production in 1982 was 740,000 tonnes. Expansion projects are underway. It is expected that by 1986 total coal production will be 3.8 million tonnes. Demand for coal is expected to rise to 3.8 million in the energy sector by 1985 due to the construction of a number of coal-fired thermal power plants.

Major projects are underway at the Enugu underground mines involving driving of about 40 kilometers of underground access roads, replacement of exhausted longwall faces and subsequent installation of additional longwall faces to facilitate the production of 2.5 million tonnes of coal per year. A total of 10 longwalls are expected to be operational by 1985.

Table 5 : Characteristics of Nigerian coals

Coal Field	Moisture (%)	Ash (%)	Volatiles (%)	Fixed carbon (%)	Calorific Value Kcal/kg
Enugu	3.50	21.60	36.40	43.00	6,243
Orukpa	8.30	8.00	43.30	48.70	6,936
Okaba	9.6	10.00	39.40	50.60	6,588

Source : Prospects for African Co-operation in coking coal for iron and steel and Related industries; ECA 1983

Other expension programmes are at Okaba open cast mines and development of new coal mines such as Orukpa and Orboyoga.

Major coal consumners in 1985 will be the Okaba coal carbonization plant (600,000 tonnes); Cement industry (500,000 tonnes) and Nigerian Steel Authority (300,000 tonnes). The Ajaukuta Steel Company is expected to import 1.2 million tonnes of coking coal in 1989.

(xii) Swaziland

Coal resources are estimated at 5,000 million tonnes In-situ (of which 1,820 million tonnes are exploitable). Important coal reserves are Mpaka, Mtendeka and Maloma. Exploration work has been sponsored by the Government

in the Mpaka area. Anglo-American Corporation of South Africa ltd (AAC) undertook this work. Shell Coal (Swaziland) Pty ltd and Sir Alfred McAlpine and Sons ltd have undertaken further exploration work. Characteristics of Swaziland coals are summarized in table below 6.

The Mpaka colliery produced 166,000 tonnes of coal in 1978. Expansion plans include a proposal to construct a 200 Megawatt thermal Power station at Mpaka colliery and the development of a new coal mine at Maloma with an annual capacity of 600,000 tonnes.

Table 6 : Characteristics of Swaziland coals

Coal Deposit	Moisture (%)	Ash (%)	Volatiles (%)	Sulphur (%)	Calorific Value MJ/kg
Mpaka	1.30	23.10	12.60	0.35	26.11
Malman		11.00	5.70	0.60	30.64

Source : Annual Report of the Geological Survey, Ministry of Industry, Mines and Tourism, 1975 (pages 10-27)

(xiii) United Republic of Tanzania

The two best known coal deposits are Mchuchuma - Ketewaka and Songwe-Kiwira coal fields. Both fields have been investigated. Coal resources are estimated at 360 million tonnes (of which 200 million tonnes are exploitables). Mchuchuma deposit covers an area of 15 square kilometers. Reserves are estimated at 187 million tonnes. The coal thickness is 20-25 meters. Of the three seams of the Mechuchuma coals the lower and middle seams have been evaluated for coking characteristics. Results showed that beneficiated coals could produce coke. Characteristics of Tanzania coals are summarised in table 7 below.

Table 7 : Characteristics of Tanzanian coals

Coal Deposit	Moisture (%)	Ash (%)	Fixed carbon (%)	Volatile matter (%)	Calorific Value (JKJ/jg)
Mchuchuma	4.5	14.30	56.15	28.85	30,600

Source : Pensibility study : Iron and steel industry based on Liganga iron ore and Mchuchuma coal BTZ; 1979

(xiv) Zambia

Coal occurs in the Karroo-system much in the same way as all coal deposits of Southern Africa. Known Zambian coal resources are in the Mid-Zambezi Valley. The Luangwa and Luano Valleys are also covered by the Karroo system. A total of 36 coal occurence throughout Zambia are recorded. The mid-Zambezi valley has 24 coal occurence of which the Siankondobo, Mulungwa, Maze-Sinakumbo and Mkandabwe have been well investigated. The total coal reserves of the Mid-Zambezi Valley are estimated at 124 million tonnes. Characteristics of the Zambian coals are summarized in table below 9.

In 1972 coal production was 958,700 tonnes from Maamba Mine-whose capacity is 1.5 million tonnes per year.

Table 8 : Characteristics of Zambian coal

Coal Deposit	Moisture (%)	Ash (%)	Volatiles matter (%)	Fixed carbon (%)	Calorific value (Btu/lb)
Siankondobo		17.40	17.40	65.40	
Kandabwe	1.90	24.50	21.85	53.30	10,230
Sinbalala	1.09	23.10	27.49	48.31	11,368
Bondo	3.53	18.38	34.22	43.87	10,760

Source : Mid-Zambezi Coal fields of Zambia, Geological survey Department, Ministry of mines.

(xv) Zimbabwe

There are two main groups of coal formations. In the north are the Middle Zambezi Valley coal formations and in the south the Sabi-Limpopo coal formations. The Wankie coal deposit is the most important of all the coal formation. The Wankie formation contains more than 3 billion tonnes of coal resources. The resources of Sabi-Limpopo Valley in the South have not been estimated. The total coal resources of Zimbabwe are in excess of 7.13 billion tonnes of coal.

The present Wankie coal concession area covers 160 square kilometers. The coking coal seam is estimated at 478 million tonnes. Characteristics of Wankie coal are summarized in table 9 below.

Production at Wankie was 2.67 million tonnes in 1981. Room-and-pillar mining method is used. As a result a large quantity of coal is left underground at roof-support. According to European experience room-and-pillar has been found to be the most inefficient of all underground mining methods resulting in a loss of up to 65 per cent of the total coal resources in the deposit 1/. In the Zimbabwe case, long wall method is not used because of the volatile nature of coal and the risk of spontaneous combustion when caving take place.

Coal from Wankies is converted into coke consummed by ZISCOSTEL and foundries in Bulawayo. High ash coal is fired at Wankie to produce electricity.

Table 9 : Characteristics of Wankie coal

Coal Deposit	Moisture (%)	Volatiles (%)	Ash (%)	Fixed carbon (%)	Calorific value (MJ/kg)
Wankie	1.00	24.00	10.00	65.00	31.40

Source : Prospects for African co-operation in coking coal for iron and steel and Related Industries, ECA 1983

1/ Economic Commission for Europe and Energy conservation : Recent Experiences and Prospects E/ECE/985; page 8, (1980)

(xvi) Development of coking coal and associated infrastructure

The coal resources of Africa outside the Republic of South Africa (RSA) belong to Coking coal of commercial value is found in Botswana, Swaziland and Zimbabwe. The rest of African coals are within weakly coking to non-coking.

The vast coal resources of Botswana, Mozambique, Swaziland and Zimbabwe offer of great potential for export earnings but its development as well as the development of associated infrastructure, including the construction of a new railway leading to the sea. This will require the consent and co-operation of neighbouring countries with a coastline as Botswana is landlocked.

Intra-African trade in coal will be constrained by well developed coal handling facilities and inadequacy of transportation infrastructure for coal. Bearing in mind that Botswana, Mozambique, Swaziland and Zimbabwe are potential exporters of coal whereas countries such as Malawi, Zambia and Malawi are potential importers, the situation regarding infrastructure will be a major constraint to coal trade.

Mozambique possesses three coal ports: Beira, Maputo and Nacala. Present capacity of Beira is 30,000 tons/year. Maputo has natural deep harbour but has limited infrastructure. Zimbabwe is a land-locked country that requires access to the sea, this is also the case with Botswana. In Nigeria the coal handling and transportation infrastructure in the form of railways, ports, harbours and terminals for coal are not in the process of development.

ANNEX I

Table 10 : Summary of the Coal Resources of African Countries (Units in billion tons)

Country	Coal resources		Lignite resources		Total exploitable coal resources (reserves)
	Geological in situ	Exploitable (reserves)	Geological in situ	Exploitable (reserves)	
Algeria	1 030	20-100	n.a.	n.a.	20
Angola	100	5	30-100	30	35
Botswana	100 000	500-5000	-	-	500
Egypt	40	5	n.a.	2	7
Ethiopia	-	-	n.a.	10	10
Madagascar	300	90-120	100	30	120
Mali	-	-	n.a.	3	3
Malawi	50	15	-	-	15
Morocco	120	40	n.a.	n.a.	40
Mozambique	400	50-100	-	-	80
Niger	-	-	60	30(?)	30
Nigeria	180	90	70	50(?)	140
Sierra Leone	-	-	n.a.	2	2
Somalia	-	-	n.a.	n.a.	?
Swaziland	1 200	1 320	-	-	1 320
United Republic of Cameroon	900	?	n.a.	n.a.	?
United Republic of Tanzania+	350	250(?)	-	-	250
Zaire	1 180	73	-	-	73
Zambia+	220	5	-	-	5
Zimbabwe	7 130	1 390	-	-	1 390
Developing Africa	112 455	2 384-9 021	230-710	157	9 543
South Africa	66 195	26 903	-	-	26 903
Total Africa	182 654	31 280-35 924	240-710	157	31 446
Total world	7 725 534	702 772	337 000	29 526	502 098
Africa %	2.37	6.36-7.29	0.33	0.005	6.02

* Sources : World Energy Conference 1977, World Bank Reports, International Geological Congress 1980, ECA Secretariat. The following have not been included; sub-economic lignite reserves in Tunisia, Egypt, United Republic of Cameroon, Benin, Nigeria, Upper Volta, etc.

+ According to local sources, the geological coal resources of the United Republic of Tanzania in 1980 may be four times higher and Zambia's exploitable coal resources seven times higher than shown here.

III. OPPORTUNITIES FOR INCREASED UTILIZATION OF COAL IN AFRICA COUNTRIES

A. Coal and other sources of energy

As an energy source, the future of coal and its role in the socio-economic development of African countries are inextricably associated with the pattern of energy uses. It is a well known fact that the evolution of energy sources from human muscles to mechanical energy brought about industrialization. Here in Africa, industrialization patterns will determine the prefered energy sources. Options of Sources of Energy for Africa's industrialization are:

(i) Fossil fuels, Coal, Crude petroleum, refined pretroleum products, natural gas, derived synthetic gases, shale oil and tar sands

(ii) Hydro-electricity and thermal electricity

(iii) Renewable energy resources : fuel wood, farm wastes, windpower, tidal, solar, geothermal energy, industrial and municipal waste

(iv) Nuclear energy

Each form of energy has a set of technologies and economics associated with primary production, extraction, transportation or supply, conversion, distribution and end-use. End-uses are basically three : power, heat and light. Industiral energy conversion modes are : electricity, industrial (such motors, engines, generators and converters), direct process heat such as steam, direct heating and firing. Consumming sectors are grouped under : residential commercial, industrial and transportation.

On the basis of costs, foreign exchange constraint and technological convenience, not all forms of energy indicated above are ideal for the African situation. Tables 11 and 12 summarize the situation quite clearly. These energy sources are not interchangeable in terms of end-use. As an example gasoline and diesel oil are the most convenient energy sources for transportation; electricity natural gas and LPG for domestic heating in urban areas; charcoal and firewood in rural areas. Electricity is the most convenient source of energy for lighting, industrial prime movers moves and domestic appliances. The issue that we are confronted with in Africa concerns the extent to which coal can be used as a primary source of electricity, synthetic substitutes for gasoline and diesel oil as well as a source of direct heat in industry and homes and also as a raw material for conversion in industrial processes to yield intermediate and final products.

Table 11 : Comparative Costs of Domestically Produced Fuels from Different Sources a/

(1980 US dollars per barrel of crude oil equivalent)

	Range of Domestic Prices	Imported Equivalent
1. Primary Energy		
Crude Oil	6.00 to 15.00	30.75 b/
Natural Gas	2.25 " 11.00	27.00 c/
Gas (manufactured)	4.50 " 15.00 d/	14.00 e/
2. Secondary Energy		
(a) Derived from Crude Oil		
Gasoline - Primary Distillate	9.40 " 21.00	43.50
- Cracking of fuel oil	11.00 " 21.00	43.50
Kerosene	11.30 " 25.40	46.00
LPG	10.00 " 25.00	42.50
Fuel Oil	7.20 " 13.50	27.75
(b) Derived from Coal		
Gasoline	40.00 " 60.00	43.50
(c) Synthetic Fuels		
Ethanol from Molasses/		
Sugarcane	25.00 " 45.00	43.50 f/
Shale oil	25.00 " 35.00	30.75
3. Renewable Energy		
Firewood	8.00 " 20.00	46.00 g/
Charcoal	30.00 " 80.00	46.00 g/

a/ Based on delivered cost to major consumers
b/ Based on posted price for Saudi Arabian Light Crude, 1st June 1980
c/ Based on Imports of liquified natural gas or fuel oil
d/ Includes cost of infrastructure
e/ Cost of imported steam coal
f/ Cost of imported gasoline
g/ Cost of imported kerosene

Source : World Bank : Report No. 3076 Energy in the Developing Countires

Table 12 : Comparative costs of power generation based on various types of fuel (Case of oil Importing Developing Countries)
(Delivered cost to major consumers)

Generator Type		Investment cost a/ US Dollars per KW Installed	Fuel Cost 1980 US¢ K'h	Power Cost 1980 US¢ K'h
Hydropower	- Large, High Head	1100	n.a.	2.1
	- Low Head Mini-Hydro	3500	n.a.	12.7
Diesel	- Large, Heavy Oil Fuel Coastal Location	1000	4.2	6.7
	- Small, Light Oil Fuel Inland Location	800	10.9	13.2
Steam	- Large, Gas-Fired	800	0.1	2.4
	- Large, Coal-Fired	1000	2.7	5.2
	- Large Oil (Imported) Fired	800	5.5	7.5
	- Small, Heavy Oil-Fired Inland Location	1400	7.3	11.1
	- Small, Wood-Fired	1500	3.0	10.00
Geothermal	- Dry Steamfield	1400	n.a.	3.0
	- Wet Steam/Hot Water Field	2800	n.a.	6.0
Nuclear	- Large Multiple Units	1500	1.0	5.1
	- Single Small Unit	2200	1.0	7.1
Solar Photovoltaic		20,000-30,000 b/	n.a.	100-300
Wind Generator		5,000-15,000 b/	n.a.	30-100

n.a. Not applicable.

a/ Investment cost includes cost of transmission and distribution

b/ Both solar energy and wind power are intermittent energy sources which require storage to make energy available on demand at all times. Investment costs given above are system costs with storage included.

Source : World Bank. Report No. 3076. Energy in the Developing Countries.

Coal is more abundant than other fossil fuels in African countries. Its technology of extraction and utilization is less complex than that of other fossil fuels. The price is also competitive in fuel and direct heat application.

B. Preconditions for increased coal utilization

The prerequisite to the expanding of coal production is an accelerated programme of exploration. General geological information in Africa is lacking hence workable coal deposits are not defined. Geological information including characteristics of African coal must be well documented and disseminated. Exploration techniques such as seismetric and seismoacoustic methods are well known. The follow-up techniques of drilling and examination of core samples are conventional. Techno-economic information relating to exploitation includes the nature of the overburdern, nature of strata between the coal seams, the thickness and dip of the seams, faulting and intercalation by bands of shale and mudstones.

Utilization of coal is guided by the physical, petrographic and chemical properties of coal. Results of proximate analysis (moisture, volatile matter, ash and fixed carbon) may be used for routine control or to establish rank of the coal or to ascertain the need for beneficiation. Results of ultimate analysis (carbon, hydrogen, nitrogen, oxygen and sulphur) are used for combustion calculations. Various applications require specification of the desired characteristics of the coal.

Having ascertained the techno-economic value of a coal deposit a decision to mine is taken. The recovery of coal is carried out either by surface or underground mining. Surface mining (open cast mining) is less costly than underground mining. There are two general methods of underground mining. In the **room-and-pillar** method, the coal is mined at relatively shallow working depth by cutting "room"s in the coal seams and leaving "pillars" between the room to support the roof. Recovery of the coal is very poor by this method.

Longwall face (two parallel headings 100-200 apart) are driven into the seam at right angles to the main heading and the coal mined from the block between. Longwall mining employs continuous mining in modern mines. In the older mines the cycle of operation involves : undercutting the seam, drilling of blasting holes, blasting, face trimming, loading and conveying by conveyor or shuttle cars. Recovery is greatly improved by this method.

Infrastructure for transportation, handling and storage of coal is a very demanding pre-condition for increased utilization of coal in African countries. Transport of coal from the pit or mine to the ultimate consumer (power station,

coke oven, whole coke depot etc.) in small quantities at present. Coal will come and for large consumers by specially designed bulk handling. Overland Canal modes of transportation are used wherever possible. The order of transport modes is the following: rail, road, inland, water, barge, and conveyor belt. Coal slurry (pulverized coal in water) is a newly developed mode of transportation. Breakthrough over the distance is the only barriers.

Coal handling and storage facilities are not new to the world of coal and large volume of materials to be handled. Utilization and spontaneous combustion must be dealt with at the design stage of facilities. Some of the modern concepts in coal handling and storage include : rail loading, stacker - reclaimer system and multi-silo loading. Since a nation will need to develop this infrastructure simultaneously as the coal industry develops, at the moment this infrastructure is inadequate.

C. Opportunities existing from interchangeability of forms of energy

There are limits to the direct replacement of one form of energy by another. There is no substitute for coke for the internal combustion engines according to the present state-of-the-art. Primary sources of gasoline and jet fuel, however, can be substituted. The demand for these fuels will continue to be heavy and light petroleum fuels.

Domestic fuel users can use natural gas, electricity, charcoal, firewood and coal. Environmental considerations may cost the major determinate of interchangeability.

Synthesis gas from coal can directly replace natural gas as the raw material for ammonia and production of ethanol needed for gasoline and aromatic hydrocarbons. This is an important area of coal substitution in Africa. Electricity is the most convenient source of energy for lighting, industrial drives and domestic appliances. It is interchangeable with other forms for direct heating, certain metallurgical heating. Its generation can be achieved by several forms of primary energy : hydro, oil fired, fuel oil fired, coal fired, wind, solar, geothermal as well as tidal.

D. Utilization of coal for electricity generation

Thermal power plants are installed as a back-up to ensure reliability of power supply in countries endowed with hydro resources. For those that are not well endowed, thermal power plants are primary sources of electricity. In coal producing countries, it is a common practice to install a coal fired

thermal power plant to utilize the low calorific value coal which would normally be discarded as overburden and would subsequently burn spontaneously. The electricity generated is counted as a credit to operations of the coal mine. As a matter of policy hydro-electricity generation is developed alongside with thermal power plants so that at peak periods the thermal power plant can supplement the power system with extra supply. Most mining installations install captive thermal power plants.

The Industrial Development Bank envisages an installed capacity of 21,000 MW by the year 2000 (an additional 20,000 MW over the existing). If we assume that about 25 per cent of this would come from coal fired plants, the potential coal market would be about 27 million tons annually for the 5,000 extra coal-fired megawatts.

F. Opportunities for coal conversion

(i) Coal gasification

The first opportunity for coal utilization by gasification is the production of low calorific value gas mixtures produced by gasifying coal with air as the oxidizing agent yielding a product suitable for steam-raising, industrial process heating or combined cycle of electric power generation. The second opportunity involves the coal gasification with oxygen and steam yielding a synthesis gas suitable for the production of synthetic coal gas (SNG), methanol, ammonia, or using the gas for the Fischer-Tropsch synthesis.

(ii) Pyrolysis and coal liquefaction

Pyrolysis is intended to produce coal based liquid fuels that would replace petroleum based crude. Liquefaction offers an opportunity for utilizing coal by producing liquid fuels by the hydrogenation of coal. Brown and bituminous coals have been experimented with yielding aviation gasoline, motor gasoline and diesel hydrocarbons. Current efforts is directed towards the production of coal-based crude oil (synthane).

(iii) Economics of coal conversion[1/]

Probable cost of syncrude depends on the experimental process used for techno-economic evaluation. Break-even costs have been estimated to be between $10-13 per barrel. Total capital costs for a commercial plant handling

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1/ Role of coal in supplying the ECE Region with Energy and Raw materials in the Light of New Techniques of Coal Conversion and Utilization; UN Economic Commission for Europe ECE/COAL/72; 10 October 1982 pages 59-60.

between 25,000 and 30,000 tonnes of coal per day are estimated at $1.5 to 2 Billion.

Under North American conditions capital costs of a 2,000 tonnes/day coal based ammonia plant using a Koppers-Totzek gasifier is $360 million (compared with $175 million for a natural gas based one of comparable capacity). A 2,000 t/d methanol plant based on Koppers-Totzek coal technology is estimated at $323 million (compared to $120 million for natural gas based comparable plant).

These few figures indicate a contradiction which is very common to process based industries. Well-tested and tried technology is cheaper than new technology. In the energy sector coal-based technology has been a response to escalating feedstock prices. Amortization of research and development costs contributes greatly to the high specific investments of coal based technology.

Numerous pilot plants have been constructed to demonstrate the techno-economic feasibility of Coal Conversion plants. Processes are diverse and conflicting claims are made with regard to their performance. It is therefore difficult to make an informed assessment of their usefulness to the African situation. It is therefore an important requirement that such evaluation be made prior to considering these conversion process as viable to our situation in Africa.

2. Increased utilization of coking coal

Iron and steel technology based on the blast furnaces and basic oxygen converter (BOF) has been adopted as a basis for developing the iron and steel industries of, Algeria, Egypt, Kenya, Morocco, Nigeria, Tunisia and Zimbabwe. By 1985, the BOF route based steel capacity will be 8.7 million tonnes and 22.0 million tonnes by the year 2000. The potential market for coking coal will be roughly 5 million tonnes in 1985 and 25 million tonnes in the year 2000.

Specifications for Metallurgical Coal are very stringent. Coals for coke-making require proper preparation before carbonization. Preparation is conducted for the purpose of reducing the ash (5-6 per cent) and sulphur (0.6 - 1.4 per cent) content. Blending ensures that coal is uniform hence the product of carbonization will also be uniform. The following reasons are advanced in support of coal preparation for metallurgical coke :

(i) high ash content means less fixed carbon in the coke and more slag volume in the blast furnace hence more coke per ton of iron and less iron production;

(ii) for each per centage point of ash reduction in blast furnace coke, some 3 - 6 per cent increase in iron production can be achieved;

(iii) high sulphur content in the coke means more limestone in the blast furnace. The iron balance will be reduced in the burden hence low blast furnace productivity;

(iv) good quality coal leads to a good coke.

Blending of coal for coking purpose is associated with uniformity of quality of the admixture and also helps to :

(i) improve the chemical and physical quality and uniformity of the coke;

(ii) control the pressure developed in the oven by carbonization process;

(iii) control the yield of products;

(iv) expand the utilization of coals with poor coking characteristics.

In view of the fact that coking coal endowed African countries will not necessarily install iron blast furnaces it is envisaged that these countries Madagascar, Mozambique, Swaziland, Tanzania, Zaire and Zimbabwe) may wish to produce coal or coke and sell their products to African countries with iron furnaces (namely : Algeria, Egypt, Morocco and Nigeria.)

STRATEGIES AND MODALITIES FOR CO-OPERATION IN COAL PRODUCTION AND UTILIZATION

1. Preconditions for co-operation

(a) Exchange of Information

An information system facilitating free flow of publications, reports of geological investigations and results of research and development is an essential means of promoting co-operation in the field of coal development. Regular seminars, study tours and Conferences relating to coal production and utilization will lead to greater awareness of the potential role of coal in African economies. Joint research and development work between African countries as well as other countries with the necessary experience in the field of coal will enhance the accumulation of expertise, experience and know-how. Algeria, Egypt and Nigeria will play a leading role in this respect.

(b) Expanding coal production

An accelerated programme of exploration is a prerequisite for expanding coal production. Exploration for coal has been the least of priorities in the mineral industries of Africa. In the past, mineral industry projects were initiated and promoted by multinational corporations who were not interested in coal. Undoubtedly major coal fields await discovery in many African countries. Research and development effort aimed at classifying and characterising the African coals will need to be undertaken. Those countries with research and development facilities will need to put themselves at the disposal of those ~~without~~ Egypt and Algeria will need to play a key role. Techno-economic information regarding mining and beneficiation will need to be collected and compiled for easy reference and use by member states. Due regard will need to be given to : improved techniques of exploration of reserves, optimized extraction technology minimization of losses, adaptation of existing technologies and development of new ones to recover untapped coal reserves.

(c) Evaluation of new technologies for coal conversion

A study group comprising experts from coal producing and consuming countries and ECA/UNIDO will need to be constituted to evaluate the numerous coal conversion technologies that have been reported in articles and paper over the last few years. The objective will be to select those that are of great promise to the African situation. These would be subjected to a much more detailed appraisal with a view to promoting cost effective coal conversion technologies for African countries in response to the escallating prices of

petroleum products. Those coal conversion technologies that will offer an opportunity for African countries to enter into the petrochemicals market will also be given attention. The study group will pay particular attention to areas where petroleum feedstocks can be replaced by coal.

B. Conclusions

By the year 2000 Africa could produce and consume 30 million tonnes of thermal coal and 25 million tonnes of coking coal. This would entail the development of new coal mines with expensive social and economic infrastructure. Planning for this investment needs to be done now. Planning should include establishment of transport and power supply net works towns and settlements with social facilities. Productive investments should also be planned now covering : thermal power stations; coke oven installations and metallurgical plants.

Development of the coal industry will require scientific, technical, research, design and development institutions to serve the needs of the coal industry. Increased coal utilization will depend on careful selection of cost effective coal conversion technologies.

C. Recommendations

(a) At national levels

Efforts at national levels will concentrate on drawing up measures aimed at improved utilization of coal reserves such as :

(i) introduction of longwall systems for coal seams where room-and-pillar methods are being used;

(ii) improvement in organization and management of coal industries including estimation of reserves, planning and development of deposits;

(iii) review and formulation of mining regulations aimed at improved utilization of coal;

(iv) undertake energy planning studies with a view to identifying areas of coal substitution and drawing up long-term supply demand balances for each source of energy;